

*Original Article***Survey of Solid Waste and Wastewater Separate and Combined Management Strategies in Rural Areas of Iran**

Mohammad Fahiminia¹, Mohsen Ansari², Shahram Nazari³, *Gharib Majidi², Vahideh Fahiminia⁴,
Simin Nasseri⁵, Amir Hossein Mahvi⁵, Ali Akbar Azimi⁶, Naser Yousefi²

1- Department of Environmental Health Engineering, Research Center for Environmental Pollutants, Qom University of Medical Sciences, Qom, Iran

2- Department of Environmental Health Engineering, School of Public Health, Qom University of Medical Sciences, Qom, Iran

3- Department of Environmental Health Engineering, School of Khalkhal Medical, Ardabil University of Medical Sciences, Ardabil, Iran

4- Department of Environmental Health Engineering, School of Public Health, Kermanshah University of Medical Sciences, Kermanshah, Iran

5- Department of Environmental Health Engineering, School of Public Health, Tehran University of Medical Sciences, Tehran, Iran

6- School of Environment, University of Tehran, Tehran, Iran

*gharibmajidi@gmail.com

(Received: 19 Jun 2014; Revised: 3 Nov 2014; Accepted: 11 Dec 2014)

Abstract

Background and Purpose: Improper wastewater and solid waste management in rural areas could be a risk to human health and environment pollution. One percent of Iran's rural area is connected to the wastewater collection network. Solid waste management in rural areas of Iran is mainly consisted uncontrolled dumping and open burning. The aim of this study is prioritization of wastewater and solid waste separate and combined management strategies in rural areas of Iran.

Materials and Methods: This was a descriptive study. In this study, firstly were determined appropriate and conventional methods for wastewater and solid waste separate and combined management by using national and case studies. Then, using specified criteria and by applying a weighting system, prioritization was conducted and implementation strategies presented for wastewater and solid waste separate and combined management.

Results: The first priority for the collection and treatment, wastewater in rural areas are small-diameter gravity systems and preliminary treatment with complementary treatment by land, respectively. In order to the rural solid waste management, organic compost complementary systems were in first priority. In the wastewater and solid waste combined management, the first priority was compost and biogas production by combining anaerobic UASB reactor and Chinese biogas.

Conclusion: Considering for influence of various factors in selecting an appropriate method is very important in order to wastewater and solid waste separate and the combined management of a rural. Therefore, the accordance of presenting strategy with local conditions and facilities should be taken into consideration.

[Fahiminia M, Ansari M, Nazari Sh, *Majidi Gh, Fahiminia V, Nasseri S, et al. **Survey of Solid Waste and Wastewater Separate and Combined Management Strategies in Rural Areas of Iran. IJHS 2014; 2(4): 27-35** <http://jhs.mazums.ac.ir>

Key words: Solid waste, Wastewater, Management, Rural areas, Iran

1. Introduction

Wastewater management inadequately led to endangering the health of millions of people around the world caused by exposure to dangerous levels of microbial and chemical pollution (1). Lack of the sufficient sanitation leads to many diseases, including Ascariasis, diarrhea, hookworm, and bilharziasis. According to estimate of the World Health Organization, 2.1 million people die annually from diarrhea (2). Four percent of all mortality in the world due to water pollution by wastewater (3). In developing countries, <18% of rural communities have access to sanitation services (4). Rural solid waste management in developing countries mainly include, uncontrolled dumping and open burning (5-9). The most obvious environmental damage caused by solid waste related to beauty. Leachate of dumping sites can contaminate surface water and groundwater (10).

Iran, with an area of 1,628,554 km² has a population of 70,495,782 people. 31.54% of Iran's population live in rural areas. Present in about 18% of urban areas and 1% of rural areas have a wastewater collection network. 5000 rural communities have a population more than 200 households (approximately 1,000 people). 90% of the rural populations have access to safe drinking water in Iran (11,12). In Iran's rural areas, groundwater is the main source of water supply and discharge of wastewater is a major cause of groundwater pollution. Contaminated groundwater, can lead to outbreaks of waterborne disease (13).

According to the National Water and Wastewater Development Program, 60% of the urban population and 30% of the rural population should be have the wastewater collection network system and treatment wastewater until 1404 years (12).

Solid waste management in Iran's rural areas is the responsibility of Ministry of Interior. Dehyaris is ordered to the collection and disposal of solid waste in rural areas. In

Iran, only 12% of rural areas are covered with the waste management system. Ordered elements of the solid waste management in Iran's rural areas system include the collection and land disposal. The Land disposal is higher as the dumping, open burning and rarely landfilling (14-16).

May provide the wastewater collection network and wastewater treatment plant separately for rural communities due to scattered locating, small-scale and complex geographic location, uneconomical and impractical (17,18). Wastewater of rural areas with low population can be treated by decentralize systems that are simpler and economical (19). These methods include septic tank, stabilization pond, wetland, and anaerobic biological treatment (18). The decentralized and semi-centralized natural treatment systems in compared to central technical systems, save energy and materials 76% and 83%, respectively (20).

Two key issues in the selection of treatment methods are affordability and appropriateness. Affordability refers to the economic situation of society whereas appropriateness refers to social and environmental conditions. In addition, the best strategy is a strategy that can be economically secure, environmentally sustainable, and socially acceptable (4). The aim of this study was prioritization of the wastewater and solid waste separate and combined management strategies in rural areas of Iran.

2. Materials and Methods

This was a descriptive study. In this study, first by using nationally and case studies was conducted in about rural wastewater and solid waste (11-15) and current situation of the country's rural areas, suggested strategies for wastewater collections, wastewater treatment, solid waste separated management and solid waste and wastewater combined management (Table 1).

Suggested strategies for collecting wastewater with the nine criteria (weight of 1-5) and the relevant sub-criteria (a score of 1-10) by designed questionnaire and accordance to views and analytical of the experts were weighted and the properties of each of the strategies and situation of each of rural were compared and prioritized ultimately (Table 2).

For prioritization of the wastewater

treatment strategies in rural areas, as for high effectiveness of type of the treatment system from the weather conditions, groundwater levels and ground texture, the country's rural areas were categorized into four groups, first (Table 3).

Then, based on criteria, treatment strategies in each of the four categories were weighted and prioritized (Table 4).

Table 1. Suggested strategies for wastewater and solid waste separate and combined management

Type of suggested strategies	Suggested strategy
Suggested strategies for collecting wastewater in rural areas	Strategy 1: Pressure sewer system Strategy 2: Vacuum sewer system Strategy 3: Small diameter gravity Strategy 4: Simplified sewer system
Suggested strategies for wastewater treatment in rural areas	Strategy 1: Absorption wells Strategy 2: Preliminary treatment with complementary treatment by land Strategy 3: Stabilization pond and wetland (natural systems) Strategy 4: Reactor systems
Suggested strategies for separate waste management in rural areas	Strategy 1: Reduce the production, source separation, temporary storage, collection, transport, processing and recycling of dry waste valuable, organic waste biocompost and disposal Strategy 2: Reduced the production, source separation, temporary storage, collection, transport, processing and recycling of dry waste valuable, anaerobic digestion (biogas) and landfill Strategy 3: Reduce the production, source separation, temporary storage, collection, transport, processing and recycling of dry waste valuable and landfill
Suggested strategies for combined management of wastewater and solid waste in rural areas	Strategy 1: On-site aeration composting (Maltrum) Strategy 2: On-site aerobic composting with pit Strategy 3: On-site anaerobic composting with pit Strategy 4: compost and biogas production by combining anaerobic UASB reactor and Chinese biogas

Table 2. Criteria for wastewater collection systems with each other and compare their weights

Criteria	Weight
Need to mechanical and electrical equipments	5
Operation and maintenance problems	4
Administration problems	4
Impact on wastewater treatment system	3
Internal diameter of the pipe and piping depth	3
Need to build septic tanks and storage tanks in the network	2
Energy consumption rate	2
Infiltration and exfiltration rate	1
Need to build manhole	1

Table 3. Rural classification based on climate, groundwater levels, and land permeability

Group	Characteristics		
	Climate	Groundwater levels	Land permeability
1	Tans'-dry and dry desert	Low	Permeable
2	Semi-arid and the Mediterranean	Low	Permeable
3	Tans'-dry and dry desert	High	Not permeable
4	Semi-arid and the Mediterranean	High	Not permeable

Table 4. Criteria for compare of wastewater treatment systems in rural areas of the country and weight

Criteria	Weight	
	Dry weather	Semi-arid and the Mediterranean
Economic	10	5
Efficiency	6	6
Ability	3	3
Needs	2	4
Environmental and health	2	3
Reuse ability	2	1

In order to the prioritization of separate solid waste management strategies in rural areas, the suggested strategies with the criteria such as required land, energy, cost, environmental impacts, and the complexity of the each process, ease of implementation, public acceptance, and recovery rates were compared, and finally were prioritized. As well as to prioritize strategies of wastewater and solid waste combined management in rural areas, the suggested strategies with criteria such as the generation of energy, costs required (construction and operation), health and environmental impacts, process complexity of construction and operation and the amount of recovered material has been compared and finally were prioritized.

3. Results

Prioritization of the strategies of collection of wastewater in rural areas is presented in table 5. The first priority is a small diameter gravity system.

Prioritization of the strategies of wastewater treatment in the country's rural areas is shown in table 6. The first priority of wastewater treatment is preliminary treatment with complementary treatment by land.

Table 5. Prioritizing strategies for wastewater collection in rural areas of the country

Priority	Type of collection system	Point
Frist	Small diameter gravity	182
Second	Simplified sewer system	123
Third	Pressure sewer system	94
Fourth	Vacuum sewer system	86

Prioritization of different solid waste management strategies is presented in table 7. Organic compost complementary systems are the first priority.

Prioritization strategies of wastewater and solid waste combined management are shown in Table 8. In wastewater and solid waste combined management, first priority is compost and biogas production by combining anaerobic UASB reactor and Chinese biogas.

4. Discussion

One important component of the wastewater management, the collection and transporting it from place generation to the treatment plant. Less than 1% of the Iran's rural areas have a wastewater collection network. As referred above, up to the years of 1404, should be having 30% of the rural population as collection networks and the wastewater treatment. Based on study results, the first priority of wastewater collection methods in

Iran's rural areas is, the small diameter gravity system and simplified sewer system is the second priority. Application of two collection methods, pressure sewer system and vacuum sewer system as for its high costs and construction and operational problems in rural areas of Iran, have less priority. In Britain, Hungary, and Finland 98, 56 and 20 percent of

rural households connects to the wastewater collection network, respectively (21). In China's rural areas, more than 97% of domestic wastewater discharge directly into the lake, river, soil or the sea and <1% of wastewater is treated (22). About half of the households in rural areas of Denmark discharge domestic wastewater to streams, lakes, or seas (23).

Table 6. Prioritizing strategies for wastewater treatment in rural areas of the country

Group	Priority	Type of system	Point
First	First	Absorption wells	186
	Second	Preliminary treatment with complementary treatment by land	168
	Third	Stabilization pond and wetland	150
	Fourth	Reactor systems	108
Second	First	Preliminary treatment with complementary treatment by land	161
	Second	Absorption wells	160
	Third	Stabilization pond and wetland	133
	Fourth	Reactor systems	122
Third and Fourth	First	Preliminary treatment with complementary treatment by land	161
	Second	Stabilization pond and wetland	133
	Third	Reactor systems	122

Table 7. Prioritizing strategies for solid waste management in rural areas of the country

Criteria	Strategy		
	Waste reduction, source separation, temporary storage, collection, recycling, organic compost and sanitary landfill	Waste reduction, source separation, temporary storage, collection, recycling, biogas and sanitary landfill	Waste reduction, source separation, temporary storage, collection, recycling and sanitary landfill
Land require	1	2	3
Energy production	2	1	3
Cost	2	3	1
Environmental impact	1	2	3
Facility and process complexity	2	3	1
Material recovery	2	1	3
Public acceptability and safety	1	2	3
Point	11	14	17
Priority	First	Second	Third

Table 8. Prioritization strategies of wastewater and solid waste combined management

Criteria	Strategy			
	Compost and biogas production by combining anaerobic UASB reactor and Chinese biogas	On-site aeration composting (Maltrum)	On-site anaerobic composting with pit	On-site aerobic composting with pit
Energy production	1	3	2	3
Cost	4	3	1	2
Health and environmental impact	1	2	4	3
Facility of construction and process operation	4	2	3	3
Material recovery	1	2	3	4
Point	11	12	13	15
Priority	First	Second	Third	Fourth

Based on the study results, in the majority of rural communities, on-site and natural treatment strategies were in first priority and reactor systems were in the last priority. Application of the absorption wells for wastewater disposal in the third and fourth rural areas due to high groundwater levels and unsuitable permeability of the ground is not possible. In areas where land is available convenient and adequate, the stabilization pond system will be possible. In rural areas of Turkey, the wastewater management methods mainly include Septic tank, absorption wells, and package systems (24). In rural areas of Jordan, the method of sanitation is cesspool (25). Appropriate methods for wastewater management in Hungary's rural areas are usage of natural wastewater treatment systems, such as, pond systems, planting trees systems and aquatic plant systems (21). The study was performed by Sharafi et al. about the efficiency of stabilization ponds, artificial wetland, activated sludge with extended aeration and conventional activated sludge in removal parasites and protozoan cysts. The results revealed that the efficiency of natural systems to remove parasite eggs and protozoan cysts are better than mechanical systems (26). The study was conducted by Dong et al. about performance processed septic tanks, biological treatment units, artificial wetlands, stabilization ponds and activated sludge treatment units in rural areas of China. Determined that Septic tank is inefficient in the reduction of nutrients and pathogens. The results revealed that the performance of activated sludge processes and artificial wetland are better than stabilization ponds and low-energy biological facilities. In this study, artificial wetland was offered for dispersed rural's population (18).

Discharge of effluent from the septic tank into the aquatic environment is inappropriate due to high total suspended solids,

biochemical oxygen demand, fecal coliform, total nitrogen and total phosphorus (27). The aerobic biological treatment units and membrane bioreactors, eliminate pollutants effectively, but the costs of operation and maintenance are high that not economical in developing countries (28,29). Artificial wetland and wastewater stabilization ponds are widely used for wastewater treatment in rural areas (20). Use of wetland depends on the weather conditions. From benefits of the wetlands can be noted to, high-efficiency pollutant removal, adaptability to changes in loading, ease of construction, operation and easy maintenance and low cost of operation (23,30). The Stabilization ponds operation and maintenance is easy and construction costs is low (31). The use of stabilization ponds can create problems in viewpoint of beauty and odor (32).

In suggested strategies for the separated management of solid waste in rural areas, waste reduction, source separation, temporary storage, collection, recycling, and sanitary landfill exist in all strategies. The results of this study revealed that composting systems are in first priority, and the producing of biogas is the second priority. Priority of recycling items in rural areas of Iran is degradable material (composting), plastic, paper, and metal (16). In a study that were performed by Abduli et al. in 21 rural areas in the Bushehr province, Iran, revealed that low-level technology composting due to the low cost of land, ease of access to labor and the low volume of biodegradable materials, in the priority (5). In a study by Jozi et al. in 22 Minab's rural areas were conducted, composting method was proposed for degradable solid waste management (33). Quality of compost produced from solid waste in the city of Babol, Iran, was assessed by Amouei et al. Quality fertilizer produced from mixed solid waste was at Class A standard of Environmental Protection America (34). Shah et al. suggested strategy of vermicompost to

solid waste management in six rural areas of India Tekanpur (6). In another study was conducted by Taboada-Gonzalez et al., in two rural areas in northern Mexico, biological digestion and composting was proposed for household solid waste management (7). In a study that was conducted by Lal et al. in rural areas of Rewa Province, India, reuse, source reduction, recycling and composting of household organic waste for rural solid waste management was proposed (9).

Prioritizing strategies of wastewater and solid waste combined management illustrated that strategy of compost and biogas production by combining anaerobic UASB reactor and Chinese biogas in first priority and the second priority is Maltrum strategy. The strategies, which energy recovery is not possible and the possibility of environmental contamination is high, having a lower priority.

Many factors involve in choosing the suitable strategy for the separate and combined management of wastewater and solid waste rural areas. Should be noted that the importance of the criteria are not the same for different projects and in each case, it is necessary to determine the coefficients of the importance of each to be selected. Since the coefficients are effective in selecting the best strategy, it is recommended that these coefficients according to the requirements, possibilities, and limitations, exact to determine. The results of this study could be used by experts as a guide in selecting the appropriate strategies for separate and combine management of wastewater and solid waste in rural areas.

Acknowledgement

Authors are grateful to the technical and instrumentation support of the Rural Water & Wastewater Company authorities of Qom province and Qom University of Medical Sciences.

References

1. World Health Organization. Water quality and health strategy 2013-2020 [Online]. [cited 2013]; Available from: URL: http://www.who.int/water_sanitation_health/publications/2013/water_quality_strategy/en/.
2. World Health Organization. Environmental Health. Amman, Jordan: Eastern Mediterranean Regional Center for Environmental Health Activities (CEHA); 2002.
3. Avsar Y, Tarabeah H, Kimchie S, Ozturk I. Rehabilitation by constructed wetlands of available wastewater treatment plant in Sakhnin. *Ecological Engineering* 2007; 29(1): 27-32.
4. Massoud MA, Tarhini A, Nasr JA. Decentralized approaches to wastewater treatment and management: applicability in developing countries. *J Environ Manage* 2009; 90(1): 652-9.
5. Abdul MA, Samieifard R, Jalili Ghazi Zade M. Rural solid waste management. *Int J Environ Res* 2008; 2(4): 425-30.
6. Shah R, Sharma US, Tiwari A. Sustainable solid waste management in rural areas. *Int J Theor Appl Sci* 2012; 4(2): 72-5.
7. Taboada-Gonzalez P, Armijo-de-Vega C, Aguilar-Virgen Q, Ojeda-Benitez S. Household solid waste characteristics and management in rural communities. *Open Waste Manag J* 2010; 3: 167-73.
8. El-Messery MA, Ismail GA, Arafa AK. Evaluation of municipal solid waste management in egyptian rural areas. *J Egypt Public Health Assoc* 2009; 84(1-2): 51-71.
9. Lal P, Tabunakawai M, Singh SK. Economics of rural waste management in the Rewa Province and development of a rural solid waste management policy for Fiji. Apia, Samoa: Secretariat of the Pacific Regional Environment Programme (SPREP); 2007.
10. Mohammadi A, Amouei A, Asgharnia H, Fallah H, Ghanami Z. A survey on the rural solid wastes characteristics in North Iran (Babol). *Univers J Environ Res Technol* 2012; 2(3): 149-53.
11. Fahimainia M. Wastewater treatment in small communities and urban areas of Iran. Qom, Iran: Ebtakar-e Danesh Publications; 2009. p. 70-95. [In Persian]

12. Fahiminia M, Fazlzadeh Davil M, Heidari M, Sadeghi H, Bakhtiari H. Survey of wastewater management status in urban areas In Iran. *J Health Hyg* 2011; 2(3): 40-7.
13. Farrokhi M, Hajrasoliha M, Memari G, Fahiminia M, Talebi M, Kohansal M. The creation of management systems for funding priorities in wastewater project in rural communities in the Islamic Republic of Iran. *Water Sci Technol* 2008; 58(6): 1181-6.
14. Fahimainia M. A report of study of investigation of solid waste management in rural communities in Iran: A National Study. Municipalitys and Dehyaris Bureau of Iran 2007: 75-94. [In Persian]
15. Fahiminia M, Aghababaei H. Environmental engineering in small communities and rural areas (water, wastewater, solid waste). 1st ed. Qom, Iran: Ebtekar Danesh; 2009. [In Persian]
16. Abdoli MA, Haghollahi A. Characteristics of processing and recycling rural solid waste case study: Iran. *J Environ Studies* 2011; 37(57): 105-12. [In Persian]
17. Engin GO, Demir I. Cost analysis of alternative methods for wastewater handling in small communities. *J Environ Manage* 2006; 79(4): 357-63.
18. Dong HY, Qiang ZM, Wang WD, Jin H. Evaluation of rural wastewater treatment processes in a county of eastern China. *J Environ Monit* 2012; 14(7): 1906-13.
19. Wilderer PA, Schreff D. Decentralized and centralized wastewater management: a challenge for technology developers. *Water Sci Technol* 2000; 41(1): 1-8.
20. Luederitz V, Eckert E, Lange-Weber M, Lange A, Gersberg RM. Nutrient removal efficiency and resource economics of vertical flow and horizontal flow constructed wetlands. *Ecological Engineering* 2001; 18(2): 157-71.
21. Ruokojärvi A. LakePromo summary-rural wastewater treatment in Finland, the United Kingdom and Hungary. Kuopio, Finland: Savonia University of Applied Sciences; 2007.
22. Ye F, Li Y. Enhancement of nitrogen removal in towery hybrid constructed wetland to treat domestic wastewater for small rural communities. *Ecological Engineering* 2009; 35(7): 1043-50.
23. Brix H, Arias CA. The use of vertical flow constructed wetlands for on-site treatment of domestic wastewater: New Danish guidelines. *Ecological Engineering* 2005; 25(5): 491-500.
24. LaGro J. Designing without nature: unsewered residential development in rural Wisconsin. *Landscape and Urban Planning* 1996; 35(1): 1-9.
25. Halalsheh M, Dalahmeh S, Sayed M, Suleiman W, Shareef M, Mansour M, et al. Grey water characteristics and treatment options for rural areas in Jordan. *Bioresource Technology* 2008; 99(14): 6635-41.
26. Sharafi K, Fazlzadehdavil M, Pirsahab M, Derayat J, Hazrati S. The comparison of parasite eggs and protozoan cysts of urban raw wastewater and efficiency of various wastewater treatment systems to remove them. *Ecological Engineering* 2012; 44(0): 244-8.
27. Carroll S, Goonetilleke A, Thomas E, Hargreaves M, Frost R, Dawes L. Integrated risk framework for onsite wastewater treatment systems. *Environ Manage* 2006; 38(2): 286-303.
28. Daude D, Stephenson T. Cost-effective treatment solutions for rural areas: design and operation of a new package treatment plant for single households. *Water Sci Technol* 2003; 48(11-12): 107-14.
29. Ren X, Shon HK, Jang N, Lee YG, Bae M, Lee J, et al. Novel membrane bioreactor (MBR) coupled with a nonwoven fabric filter for household wastewater treatment. *Water Res* 2010; 44(3): 751-60.
30. Siracusa G, La Rosa AD. Design of a constructed wetland for wastewater treatment in a Sicilian town and environmental evaluation using the emergy analysis. *Ecol Model* 2006; 197(3): 490-7.
31. Nelson KL, Cisneros BJ, Tchobanoglous G, Darby JL. Sludge accumulation, characteristics, and pathogen inactivation in four primary waste stabilization ponds in central Mexico. *Water Res* 2004; 38(1): 111-27.
32. Garca J, Mujeriego R, Obis JM, Bou J. Wastewater treatment for small communities in Catalonia (Mediterranean region). *Water Policy* 2001; 3(4): 341-50.

33. Jozi SA, Dehghani M, Zarei M. Rural waste management strategic plan by A'WOT method (Case study: Minab). J Environ Studies 2012; 38(64): 93-108. [In Persian]
34. Amouei AA, Asgharnia HA, Khodadi A. Study of compost quality from rural solid wastes (Babol, Iran). J Mazandaran Univ Med Sci 2010; 19(74): 55-61. [In Persian]